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(54) **SERIAL BUS HUB WITH LOW POWER DEVICES**

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See application file for complete search history.

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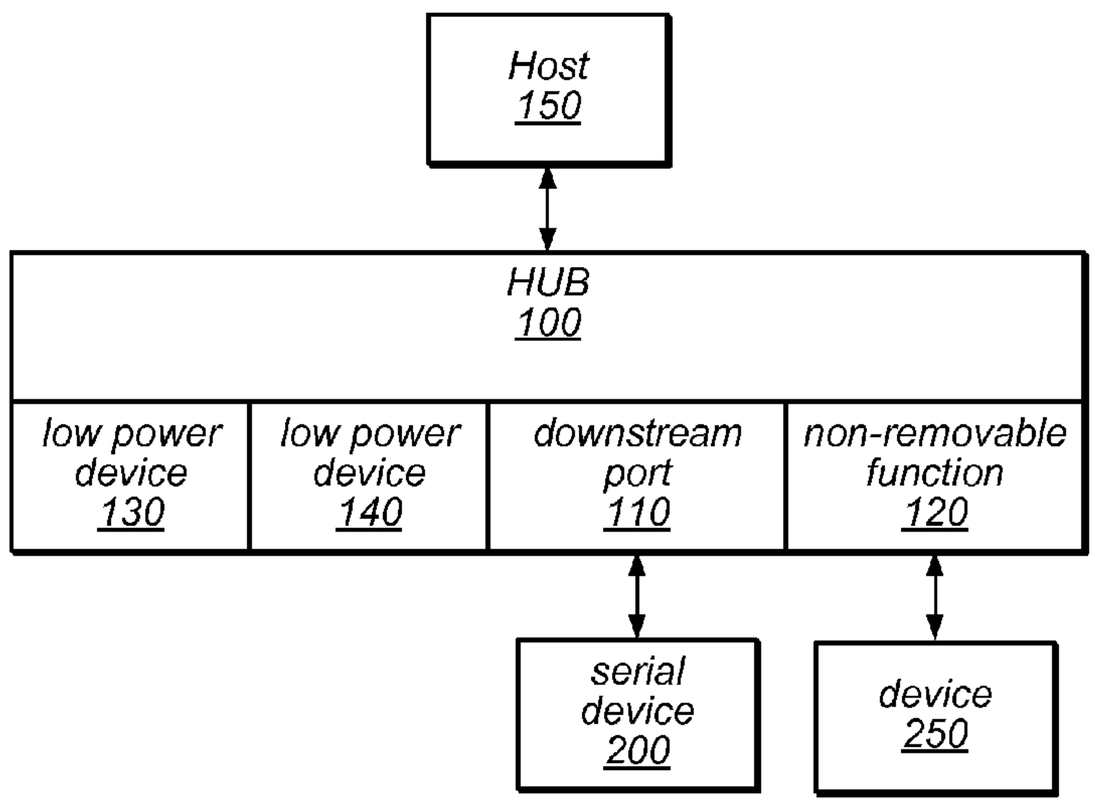
(57) **ABSTRACT**

Serial bus hub with one or more low power devices. The serial bus hub may include at least one upstream port for coupling to a host system. The serial bus hub may include one or more downstream ports for coupling to peripheral devices. The serial bus hub may include the low power devices which may have no functionality external to the serial bus hub. The presence of the low power devices may allow the serial bus hub to draw additional power from the host system and a substantial portion of the additional power may be usable by other devices. The serial bus hub may be configured to allow the host system and one or more peripheral devices coupled to the one or more downstream ports to communicate.

23 Claims, 3 Drawing Sheets



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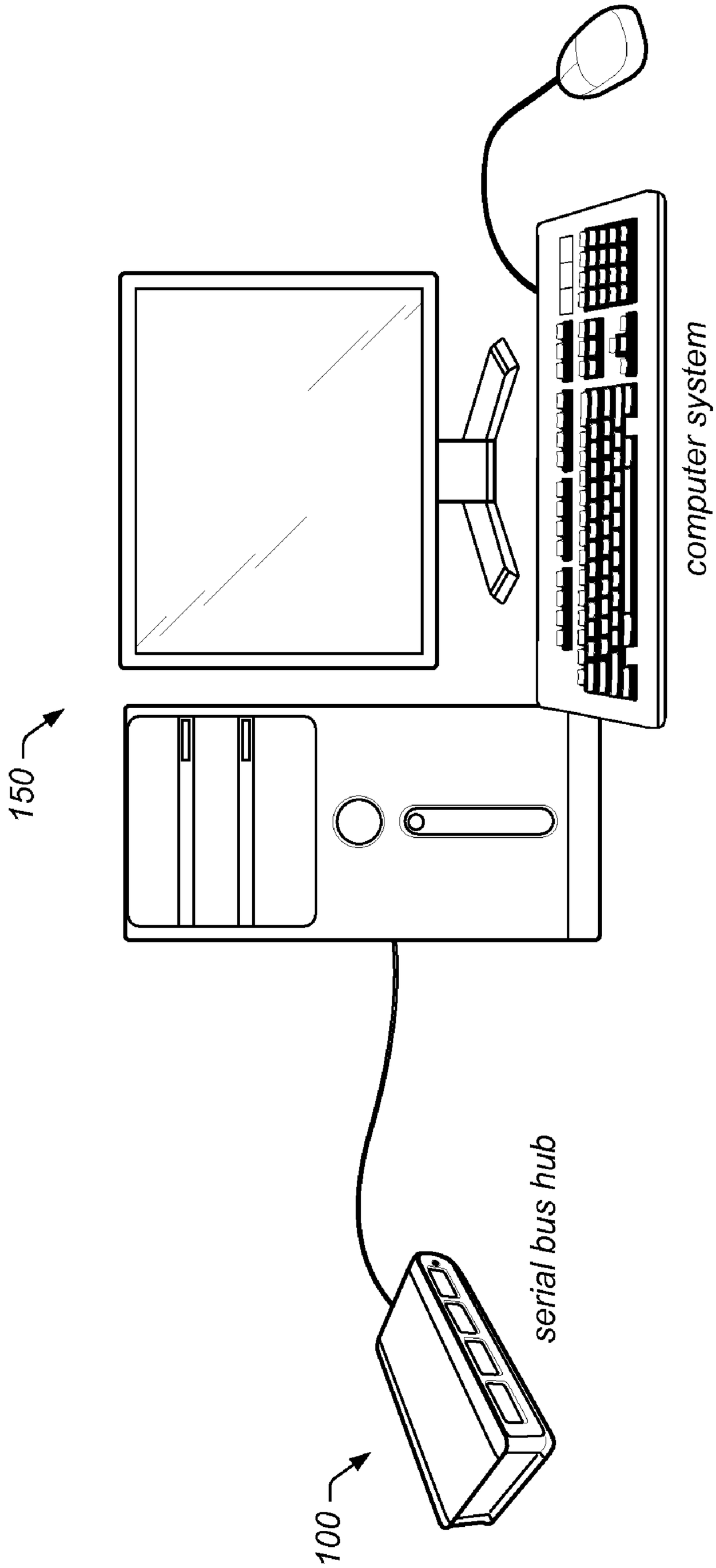

FIG. 1

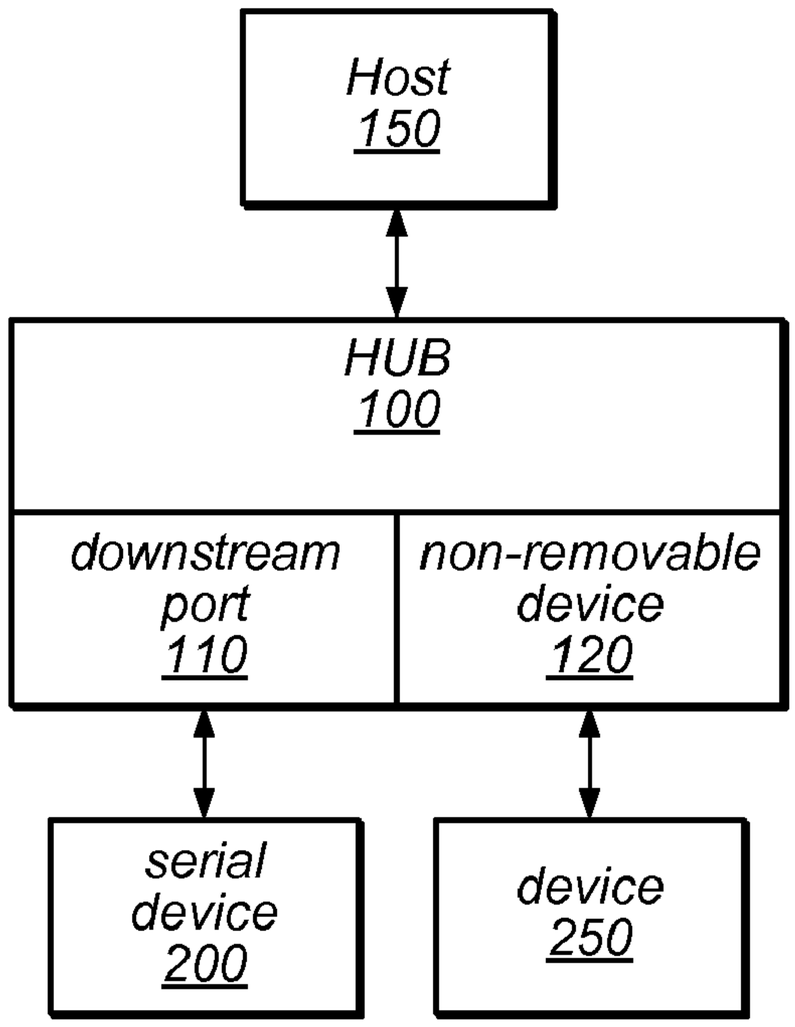
Host
150
HUB
100
downstream
port
110
non-removable
device
120
serial
device
200
device
250

FIG. 2

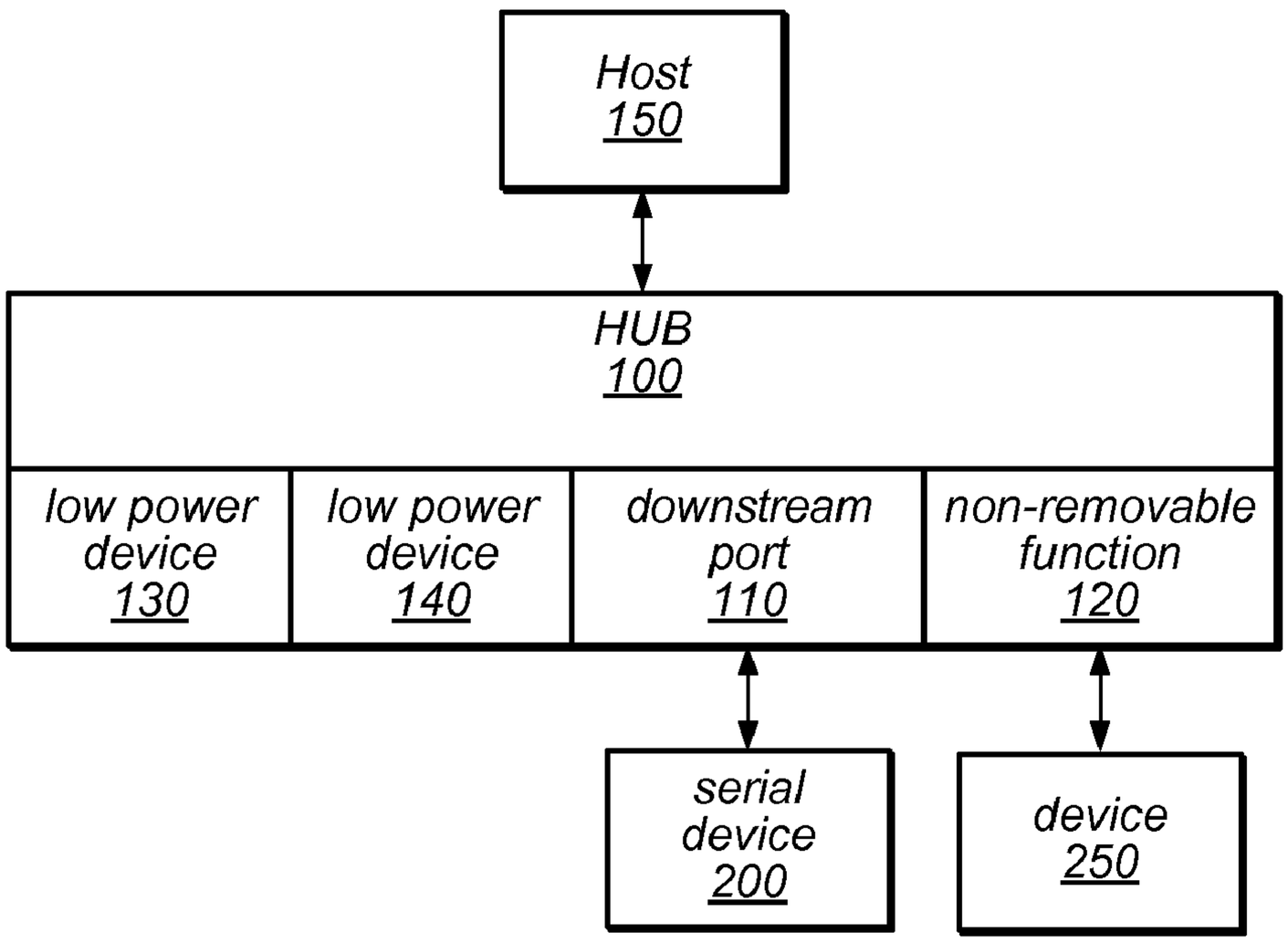
Host
150
HUB
100
low power
device
130
low power
device
140
downstream
port
110
non-removable
function
120
serial
device
200
device
250

FIG. 3

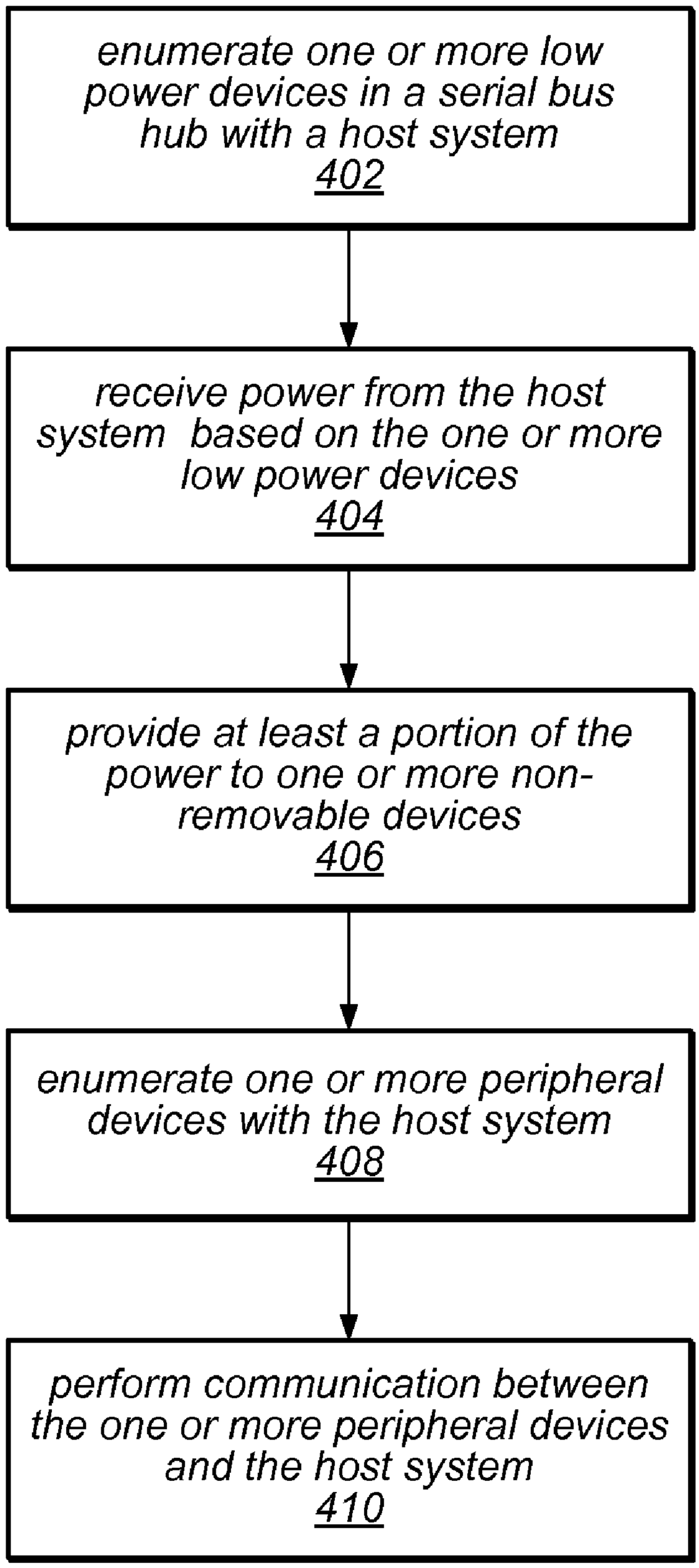
enumerate one or more low power devices in a serial bus hub with a host system
402
receive power from the host system based on the one or more low power devices
404
provide at least a portion of the power to one or more non-removable devices
406
enumerate one or more peripheral devices with the host system
408
perform communication between the one or more peripheral devices and the host system
410

FIG. 4

SERIAL BUS HUB WITH LOW POWER DEVICES

FIELD OF THE INVENTION

The present invention relates to the field of serial bus hubs, and more particularly to a serial bus hub including one or more low power devices.

DESCRIPTION OF THE RELATED ART

In recent years, serial busses, especially universal serial busses (USBs) have become increasingly popular. For example, almost every type of peripheral device uses serial communication with a host. Accordingly, serial bus hubs have also become popular. Serial bus hubs are now included in a variety of devices, such as monitors, printers, docking stations, etc. However, passive serial bus hubs, which receive their power from the host, are often hamstrung by specified power limitations.

Some prior art systems overcome power limitations by simply drawing more power than is permitted; however, such solutions are typically not permitted by various specifications (e.g., the USB specification) and can cause a variety of problems. For example, some battery powered devices may experience reduced battery lifetime using such solutions.

Accordingly, improvements in serial bus hubs are desired.

SUMMARY OF THE INVENTION

Various embodiments are presented of a serial bus hub with one or more low power devices.

A serial bus hub (e.g., a universal serial bus (USB) hub) may include an upstream port (e.g., at least one upstream port). The upstream port may be configured to couple to a host system.

The serial bus hub may include one or more downstream ports coupled to the upstream port. The one or more downstream ports may each be configured to couple to a peripheral device.

The serial bus hub may include one or more low power devices coupled to the upstream port. The one or more low power devices may have no functionality external to the serial bus hub and the presence of the one or more low power devices may allow the serial bus hub to draw additional power (e.g., 100 mA for each low power device) from the host system. A substantial portion of the additional power from the host system may be usable by other devices. In other words, in one embodiment, the one or more low power devices may be present substantially only for the purpose of allowing the serial bus hub to draw additional power, which may then be used by other devices.

The serial bus hub may be configured to allow the host system and one or more peripheral devices coupled to the one or more downstream ports to communicate.

In some embodiments, the serial bus hub may include one or more non-removable devices coupled to the upstream port. The one or more non-removable devices may draw at least a portion of the additional power from the host system. The one or more non-removable devices may include a network communication controller (e.g., an Ethernet controller) for communicating over a network (e.g., an Ethernet network). Thus, the serial bus hub may include a network port coupled to the network communication controller for coupling to the network. The number of the one or more low power devices is based on the power required by the one or more non-removable devices.

The serial bus may be included in a docking station, a printer, and/or another type of device. The serial bus hub may be a passive serial bus hub which receives power from the host system.

The method may include enumerating the one or more low power devices in the serial bus hub with a host system.

Accordingly, power may be received from the host system based on the one or more low power devices. At least a portion of the power may be provided to one or more non-removable devices in the serial bus hub instead of the one or more low power devices.

One or more peripheral devices may also be enumerated with the host system. The peripheral devices may be coupled to corresponding downstream ports of the serial bus hub with the host system. Accordingly, communication between the one or more peripheral devices and the host system may be performed. A second portion of the power above may be provided to the one or more peripheral devices.

In various embodiments, the method described above may be implemented as program instructions stored on a memory medium (e.g., firmware of the serial bus hub), in a programmable hardware element, such as a field programmable gate array, and/or an application specific integrated circuit (ASIC), as desired.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. **1** illustrates an exemplary serial bus hub coupled to a computer system according to an embodiment of the present invention;

FIG. **2** is a block diagram of an exemplary serial bus hub which includes a non-removable function according to an embodiment of the present invention;

FIG. **3** is a block diagram of an exemplary serial bus hub which includes one or more low power devices according to one embodiment; and

FIG. **4** is a flowchart diagram illustrating one embodiment of a method for enumerating one or more low power devices in a serial bus hub, according to one embodiment.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Terms

The following is a glossary of terms used in the present application:

Memory Medium—Any of various types of memory devices or storage devices. The term "memory medium" is intended to include an installation medium e.g., a CD-ROM, floppy disks, or tape device; a computer system memory or random access memory such as DRAM, DDR RAM, SRAM, EDO RAM, Rambus RAM, etc.; or a non-volatile memory such as a magnetic media, e.g., a hard drive, optical storage, flash memory, etc. The memory medium may comprise other

types of memory as well, or combinations thereof. In addition, the memory medium may be located in a first device in which the programs are executed, or may be located in a second different device which connects to the first device over a network, such as the Internet. In the latter instance, the second device may provide program instructions or data to the first device for execution or reference. The term "memory medium" may include two or more memory mediums which may reside in different locations, e.g., in different computers that are connected over a network.

Software Program—the term "program" or "software program" is intended to have the full breadth of its ordinary meaning, and includes any type of program instructions, code, script and/or data, or combinations thereof, that may be stored in a memory medium and executed by a processor. Exemplary software programs include programs written in text-based programming languages, such as C, C++, Pascal, Fortran, Cobol, Java, assembly language, etc.; graphical programs (programs written in graphical programming languages); assembly language programs; programs that have been compiled to machine language; scripts; and other types of executable software. A software program may comprise two or more software programs that interoperate in some manner.

Computer System—any of various types of computing or processing systems, including a personal computer system (PC), mainframe computer system, workstation, network appliance, Internet appliance, personal digital assistant (PDA), television system, grid computing system, or other device or combinations of devices. In general, the term "computer system" can be broadly defined to encompass any device (or combination of devices) having at least one processor that executes instructions from a memory medium.

FIGS. **1**—Computer System Coupled to Serial Bus Hub

FIG. **1** illustrates one embodiment of a serial bus hub **100** coupled to a host system **150**. The host system **150** may be any of various host devices; more specifically, the host system **150** may be a computer system and/or other types of host devices operable to perform various embodiments described herein. Alternatively, or additionally, the host system **150** may be a serial bus device, e.g., a USB device. For example, in one embodiment, the host system **150** may be a USB on-the-go (OTG) device which may be operable to act as a host and a device, e.g., depending on the situation. Thus, according to various embodiments the host system **150** may be any of various appropriate devices.

The exemplary host system **150** of FIG. **1** may include a display device operable to display video or other signals. Additionally, the computer system **150** may include a keyboard and/or mouse, which may be serial devices. The keyboard and/or mouse may couple to the host system **150** via a variety of ways, e.g., directly to the host system **150** or via the serial bus hub **100**, among other methods. Additionally, the host system **150** may include at least one memory medium on which one or more computer programs or software components may be stored. For example, the memory medium may store operating system software, as well as other software for operation of the host system **150**. Various embodiments further include receiving or storing instructions and/or data implemented in accordance with the foregoing description upon a carrier medium.

In some embodiments, the serial bus hub **100** may be a Universal Serial Bus (USB) hub. In one embodiment, the serial bus hub **100** may be a passively powered hub, e.g., a USB Bus-Powered Hub. The serial bus hub **100** may include a non-removable device. For example, the serial bus hub may include an Ethernet controller, a display, an audio playback device, and/or any type of appropriate non-removable device.

The serial bus hub may be included as a component within various devices or may be a stand alone serial bus hub, as desired. In various embodiments, the serial bus hub may be included in a docking station (e.g., for a laptop), a printer, a display, etc. The serial bus hub **100** may include one or more ports for coupling to various devices, e.g., various serial bus devices, such as USB devices and/or the host system **150**. Thus, the serial bus hub **100** may be powered passively by the host system **150** (although it may be possible that the serial bus hub **100** receive alternate or additional power from another source).

Various serial bus devices may be coupled to the serial bus hub **100**. For example, the serial bus device could be a cell phone, a personal music player (e.g., an mp3 player, and/or an IPOD™, among other players, a CD player, etc.), a personal video player (e.g., a digital video player, a DVD player, etc.), a peripheral or input device (e.g., a printer, a game controller, touchpad, mouse, and/or keyboard, among others), or any other type of serial device.

Note that the above descriptions of the host system **150** and the serial bus hub **100** (and components therein, e.g., input devices) are exemplary only and other components and systems are envisioned.

FIGS. **2** and **3**—Exemplary Block Diagrams of the Serial Bus Hub

FIGS. **2** and **3** are exemplary block diagrams of the serial bus hub **100**. As shown in FIG. **2**, the serial bus hub **100** may be coupled to the host system **150**. The serial bus hub may include at least one downstream port **110** (e.g., a USB port) which may couple to a serial device **200** (e.g., a USB device). Note that while FIGS. **2** and **3** illustrate a single downstream port, a plurality of downstream ports are envisioned. The serial bus hub **100** may also include non-removable device **120** which may couple to device **250**. As indicated above, the non-removable device **120** may be any of a variety of devices, such as a network communication controller (e.g., an Ethernet controller), which may couple to a network device (e.g., the device **250**, which could be an Ethernet device). Where the non-removable device **120** is a network communication controller, the serial bus hub may include a network port coupled to the network communication controller and the network port may be configured to couple to a network. Similar to above, there may be more than one non-removable device according to some embodiments.

As shown in FIG. **3**, the serial bus hub **100** may further include one or more low power devices (**130** and **140**). The low power devices **130** and **140** may have limited or no functionality. In some embodiments, the low power devices **130** and **140** may have no functionality outside of the serial bus hub **100**. Said another way, the low power devices **130** and **140** may provide no functionality to systems or devices external to the serial bus hub **100**. For example, the low power devices may have no functionality other than the ability to enumerate as devices with the host **150**. The low power devices may not be able to couple to (i.e., may not have a port on the serial bus hub **100**) any external devices. In some embodiments, the low power devices may only respond to the host when interrogated and may only have a control endpoint.

In some embodiments, the low power devices may not physically exist (e.g., they could be "virtual" devices that appear to exist to host software entities, but do not actually exist physically in hardware or software), thereby reducing implementation cost and electrical power consumption. The serial bus hub may include logic (e.g., circuitry or program

instructions in a memory medium) which is configured to enumerate the virtual low power devices with the host system. Thus, the low power devices may be physically present in the serial bus hub or may be virtual devices, as desired.

The low power devices **130** and **140** may allow the serial bus hub to receive or draw additional power from the host system **150**. For example, each low power device may allow the serial bus hub to draw an additional 100 mA of power. Because the low power devices have limited or no functionality, this additional power may be provided to other devices of (or coupled to) the serial bus hub **100**. For example, the additional drawn power (due to the low power device(s)) may be directed towards the non-removable device **120**. More specifically, in some embodiments, at least a substantial portion of the additional power provided from the host **150** (due to the presence of the low power devices) may be usable for other devices of the serial bus hub **100** (e.g., non-removable device **120**, the serial device **200**, and/or other devices). As used herein "at least a substantial portion of the additional power" may refer to 95%-100% of the power provided based on the low power devices. For example, the presence of low power device **130** may allow an additional 100 mA to be drawn by the serial bus hub **100**. The low-power device may consume less than 1 mA to operate (e.g., enumerate and/or remain responsive to the host **150**), and the remaining portion of the power (>99 mA) may be provided to other devices (e.g., the non-removable device **120**). In alternate embodiments, "at least a substantial portion of the additional power" may refer to 90%, 80%, or 75% (among other possible similar percentages) of the power.

In some embodiments, the number of the one or more low power devices may be based on the amount of power required by the non-removable device **120**. For example, if the non-removable device **120** requires 250 mA to operate, two low power devices may be included into the hub to be able to draw enough power for the non-removable device (100 mA allotted for the non-removable device and 100 mA each for the low power devices, summing to 300 mA). Thus, in one embodiment, one or more non-removable devices may draw at least a portion of the additional power provided from the host system based on the presence (e.g., the enumeration of) the low power devices.

To further illustrate this example, the following table indicates the actual power draw and the reported power draw (to the host system **150**):

Device	Actual Power Draw	Reported Power Draw
Non-Removable Device 120	250 mA	0 mA
Downstream Port 110	100 mA	100 mA
Low Power Device 130	~0 mA	0 mA
Low Power Device 140	~0 mA	0 mA
Serial Bus Hub 100	100 mA	400 mA

Thus, in this example, the hub may report 400 mA in its configuration descriptor while the downstream port **110**/device **200** reports 100 mA. The non-removable device **120** and low power devices **130** and **140** may report themselves as bus powered with a current draw of 0 mA.

In this case, the power reported by the hub is the sum of the power allocations permitted by the host **150** (e.g., according to USB specification): 100 mA for each of the hub controller, the low power device **130**, the low power device **140**, and the non-removable device **120**. The actual power draw (as indicated in the table above) is 450 mA while the reported power draw is 500 mA, which may be specification compliant (e.g., USB specification compliant). Thus, in one embodiment, the number of low power devices may be dependent on the number of non-removable devices and their actual power draw.

In alternate embodiments, the number of the one or more low power devices may be determined based on the maximum amount of drawable power. For example, where the maximum amount of power drawn by the serial bus hub is 500 mA (e.g., as specified in the USB specification), the serial bus hub may include enough low power devices to draw the maximum amount. As one example, the serial bus hub **100** may include a serial bus hub controller (which may be allotted 100 mA by the host **150**), the non-removable device **120** (which may be allotted 100 mA by the host **150**), and the downstream port **110** (which may be allotted 100 mA by the host **150** when a device is coupled or enumerated). Thus, to achieve the total draw of 500 mA, at least two more low power devices may be included in the serial bus hub (each allotted 100 mA by the host **150**).

In some embodiments, the low power devices may be selectively activated when additional power is required. For example, the serial bus hub **100** may include a plurality of low power devices and may enumerate with the host **150** as more power is required. As a specific example, the serial bus hub **100** may only require 100 mA at a first time to operate, but later (e.g., when the non-removable device **120** is turned on or otherwise used) additional power may be required (e.g., 250 mA). Accordingly, one or more of the low power devices may be activated or enumerated so that the additional power can be drawn and provided to the serial bus hub (e.g., for the non-removable device **120**).

By using the low power device(s), the serial bus hub may be in compliance of a standard (e.g., by not drawing more power than is allowed for just the hub **100**, the non-removable device **120**, and/or the serial device **200**). These power requirements may be specified by a serial bus hub specification, e.g., the USB specification (e.g., USB specification 2.0). In some embodiments, the serial bus hub **100** may only be allowed to draw up to 500 mA total (e.g., regardless of the number of devices included in or coupled to the serial bus hub **100**). Such embodiments may be particularly useful where the non-removable device **120** requires more than 100 mA to operate (as is typically the case for an Ethernet controller).

FIG. **4**—Enumerating Low Power Devices in a Serial Bus Hub

FIG. **4** illustrates a method for enumerating low power devices in a serial bus hub. The method shown in FIG. **4** may be used in conjunction with any of the computer systems or devices shown in the above Figures, among other devices. In various embodiments, some of the method elements shown may be performed concurrently, in a different order than shown, or may be omitted. Additional method elements may also be performed as desired. As shown, this method may operate as follows.

In **402**, one or more low power devices may be enumerated (or otherwise identified with a host system). The one or more low power devices may be included in a serial bus hub (e.g., the serial bus hub **100** described above) and may be enumerated with respect to a host system (e.g., the host system **150** described above). For example, the low power devices may enumerate with the host system according to the enumeration methods outlined in the USB specification (which is hereby incorporated by reference as though fully set forth herein). As indicated above, the low power devices may have limited functionality and may have no functionality external to the serial bus hub.

In **404**, power may be received from the host system based on the presence or enumeration of the low power devices in **402**. As indicated above, each low power device (e.g., each enumerate low power device) may allow the serial bus hub to draw an additional 100 mA (although other values are envisioned) up to a maximum amount of power (e.g., 500 mA for the whole serial bus hub, or 400 mA for all of the devices of the serial bus hub).

In **406**, at least a portion (e.g., a substantial portion) of the power received in **404** may be provided to one or more non-removable devices (e.g., similar to the non-removable device **120** described above) of the serial bus hub **100**.

In **408**, one or more peripheral devices (e.g., device **200** described above) coupled to the serial bus hub may be enumerated with respect to the host system. In some embodiments, some of the additional power provided based on the low power devices may be provided to the one or more peripheral devices, e.g., if the peripheral devices require additional power. Thus, in some embodiments, the additional power may be split among the non-removable devices and/or the peripheral devices. In alternate embodiments, however, the substantial portion of the power received based on the low power devices may be provided only to the non-removable device(s).

In **410**, communication between the peripheral devices and the host system may be performed. More specifically, communication between the peripheral devices and the host system may be conveyed by the serial bus hub. The communication may include various synching communications, transfers of data (e.g., audio data, contact data, personal data), firmware updates for the peripheral devices, etc. Similarly, communication between the non-removable device(s) and the host system may be performed.

Although the embodiments above have been described in considerable detail, numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such variations and modifications.

We claim:

1. A serial bus hub, comprising:

an upstream port, wherein the upstream port is configured to couple to a host system;

one or more downstream ports coupled to the upstream port, wherein the one or more downstream ports is each configured to couple to a peripheral device;

one or more low power devices comprised in the serial bus hub and coupled to the upstream port, wherein the one or more low power devices have no functionality external to the serial bus hub, wherein the presence of the one or more low power devices allows the serial bus hub to draw additional power from the host system, and wherein a substantial portion of the additional power from the host system is usable by one or more peripheral devices coupled to the one or more downstream ports;

wherein the serial bus hub is configured to allow the host system and the one or more peripheral devices coupled to the one or more downstream ports to communicate.

2. The serial bus hub of claim **1**, wherein the serial bus hub is a Universal Serial Bus (USB) hub.

3. The serial bus hub of claim **1**, further comprising:

one or more non-removable devices coupled to the upstream port, wherein the one or more non-removable devices draw at least a portion of the additional power from the host system.

4. The serial bus hub of claim **3**, wherein the number of the one or more low power devices is based on the power required by the one or more non removable devices.

5. The serial bus hub of claim **3**, wherein the one or more non- removable devices comprise a network communication controller for communicating over a network.

6. The serial bus hub of claim **5**, wherein the serial bus hub further comprises:

a network port coupled to the network communication controller, wherein the network port is configured to couple to the network.

7. The serial bus hub of claim **1**, wherein each of the one or more low power devices allows the serial bus hub to draw an additional 100 mA.

8. The serial bus hub of claim **1**, wherein the serial bus hub is comprised in a docking station.

9. The serial bus hub of claim **1**, wherein the serial bus hub is comprised in a printer.

10. The serial bus hub of claim **1**, wherein the serial bus hub is a passive serial bus hub.

11. A method, comprising:

enumerating one or more low power devices comprised in a serial bus hub with a host system, wherein the one or more low power devices have no functionality external to the serial bus hub, wherein the serial bus hub is coupled to the host system via an upstream port of the serial bus hub, wherein the enumeration of the one or more low power devices comprised in the serial bus hub allows the serial bus hub to draw additional power from the host system, and wherein a substantial portion of the additional power from the host system is usable by other devices;

receiving power from the host system based on the one or more low power devices;

providing at least a portion of the power to one or more non-removable devices in the serial bus hub instead of the one or more low power devices.

12. The method of claim **11**, further comprising:

enumerating one or more peripheral devices coupled to corresponding downstream ports of the serial bus hub with the host system; and

performing communication between the one or more peripheral devices and the host system.

13. The method of claim **12**, further comprising:

providing a second portion of the power to the one or more peripheral devices.

14. The method of claim **11**, wherein the serial bus hub comprises a Universal Serial Bus (USB) hub.

15. The method of claim **11**, wherein the number of the one or more low power devices is based on the power required by the one or more non-removable devices.

16. The method of claim **11**, wherein the one or more non-removable devices comprise a network communication controller for communicating over a network.

17. The method of claim **11**, wherein enumeration of each of the one or more low power devices allows the serial bus hub to draw an additional 100 mA.

18. The method of claim **11**, wherein the serial bus hub is comprised in a docking station.

19. The method of claim **11**, wherein the serial bus hub is comprised in a printer.

20. The method of claim **11**, wherein the serial bus hub is a passive serial bus hub.

21. The method of claim **11**, wherein the low power devices are physical low power devices that are physically present in the serial bus hub.

22. The method of claim 11, wherein the low power devices comprise virtual low power devices.

23. A serial bus hub, comprising:

an upstream port, wherein the upstream port is configured to couple to a host system;

one or more downstream ports coupled to the upstream port, wherein the one or more downstream ports are each configured to couple to a peripheral device;

first logic, wherein the first logic is configured to enumerate one or more virtual low power devices, wherein the one or more virtual low power devices are not physically present in the serial bus hub, wherein the one or more virtual low power devices have no functionality external to the serial bus hub, wherein the enumeration of the virtual one or more low power devices allows the serial bus hub to draw additional power from the host system, and wherein a substantial portion of the additional power from the host system is usable by one or more peripheral devices coupled to the one or more downstream ports;

wherein the serial bus hub is configured to allow the host system and the one or more peripheral devices coupled to the one or more downstream ports to communicate.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,882,297 B2
APPLICATION NO. : 12/389538
DATED : February 1, 2011
INVENTOR(S) : Sisto et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 8, Claim 4,
Line 3, please delete "non removable devices" and substitute -- non-removable devices --.

Signed and Sealed this
Third Day of May, 2011

David J. Kappos
Director of the United States Patent and Trademark Office